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The Aerovox Research Worker

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Power Supplies

PART 1

By the Engineering Department, Aerovox Corporation

THE 1936 model receivers employ power packs of varying complexities. Some of them are so involved that their function is often not readily understood from the usual serviceman's diagram. Others are so simple as to make their operation readily apparent. It seems desirable to examine the various types of power supplies, explain their functions and discuss their advantages and limitations. This is done below; all the circuits shown in this issue of the Research Worker are employed in commercial receivers released during the last year.

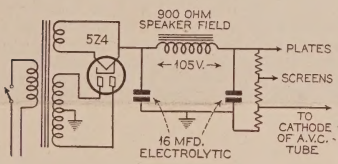

Fig. 1

The primary function of a power supply is to furnish the required a.c. and d.c. voltages to the tubes, properly filter the plate supply so as to avoid hum and have satisfactory regulation. All this has to be accomplished in the most economical manner and without causing the parts to overheat or to induce hum in the amplifiers or detector circuits. Usually the power supply also provides the necessary current for one or more speaker fields.

While discussing power supplies it is best to divide them into large groups. There are power supplies for a.c. only, others for d.c. only, some for a.c. and d.c., etc. In this article the d.c. supply will be omitted because few of them exist at the present time.

A.C. POWER SUPPLIES

The fewest parts which are employed in a practical power supply are a power transformer, a rectifier-tube and one filter section consisting of a choke and two electrolytic condensers. Generally the choke can be the speaker field, thus killing two birds with one stone. Figure 1 shows such a circuit which has become very popular for the smaller and even the medium sized receiver. The resistance of the choke must be correctly chosen so the total current drawn by the receiver is just sufficient to produce the required excitation in the electromagnetic field of the speaker.

The circuit of Figure 1 is nearly the most economical one for small receivers. It is generally used with sets of relatively low sensitivity because there is only one filter section and any hum which reaches any of the early amplifying stages has only a limited amount of audio amplification. So, if this amplification is not too much the hum in the speaker can be kept at a negligible level. Some small receivers will also be found to employ some form of hum-bucking coil in the voice coil circuit.

Note that Figure 1 shows a voltage divider consisting of high-resistance units of the carbon type. The heavy bleeder of a few years ago is very little used nowadays. It is of course well known that in cases where a heavy bleeder is absent, the voltage of the B-supply will vary somewhat with the total current drain. The largest variation in drain is usually caused by the a.v.c. circuit which changes the bias on several tubes. In one case the plate voltage on the r.f. amplifier was 240 volts with a strong signal coming in but it dropped to 225 volts without a signal. The result may be a slight shifting in the oscillator frequency. Servicemen should keep these facts in mind when servicing such a receiver. It is then best to carry out the alignment procedure with a weak signal.

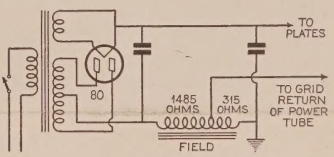

Fig. 2

Another consequence of the lack of a voltage divider is a high-voltage surge when the receiver is turned on. There is no drain on the plate supply until the tubes have heated up, a matter of 10 to 15 seconds while the rectifier heats within two seconds. In such cases the voltage may go up to 500 volts temporarily, or even higher. The electrolytic condensers should then be chosen so as to withstand these surges. In the case of some rectifier tubes the surge does not occur because the rectifier heats as slowly as the rest of the tubes, so by the time

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the power supply delivers plate voltage, the tubes are ready to draw plate current.

Returning now to Figure 1, it is seen that there is a drop of 105 volts across the speaker field; consequently

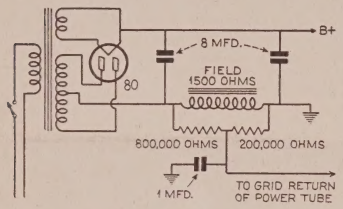

Fig. 3

when making up the specifications for the power transformer, 105 volts must be added to the required plate voltage. It will occur to some that this is a waste and one would like to make use of this or at least a part of this wasted voltage. When the field coil is placed in the negative side of the filter, it becomes possible to utilize a part of the voltage drop as a C-bias supply. This is shown in Figure 2. A tap on the field coil has been so chosen as to provide the correct voltage drop for the grid bias of the power tube. Obviously, this bias supply needs additional filtering but this is not hard to do because no current is drawn from the tap a high resistance can be used in conjunction with a condenser.

Sometimes a field coil with the proper tap might not be available. In that case the same result can be ob-

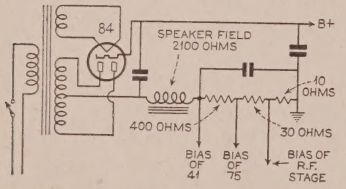

Fig. 4

tained by connecting a tapped resistor across the choke or field as illustrated in Figure 3. The total resistance of this branch should be more than ten times the reactance of the choke in order not to impair the filtering efficiency. This was explained in last month's Research Worker.

There is of course no objection to obtaining more than one C-bias from the parallel resistor. It is also possible to use a series resistance and tap it so as to provide one or more tubes with a negative bias; this is shown in Figure 4. Such a series-resistor should be small in comparison to the reactance of the choke.

A modified way of doing the same thing is shown in Figure 5. Here the choke is in the positive side and a tapped resstor is in the negative side to provide a C-bias. Note that both bias supply lines have additional filtering.

The question will be raised as to whether there is any objection to the placement of the choke in the nega-

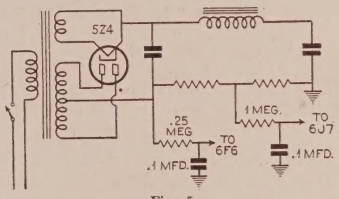

Fig. 5

tive lead or in the positive lead. Theoretically it should be the same but Prof. F. E. Terman and S. B. Pickles in the proceedings of the I.R.E. for August, 1934 point out the possibility that there may be some residual hum when the choke is in the negative side. This is due to the capacity between the secondary of the transformer and the electrostatic shield; no matter how much filtering is added, the residual hum cannot be removed, unless the positive side of the power supply is grounded.

The different forms of negative leg filtering have now been exhausted and so we return to the filters with the choke in the positive side. Figure 6 shows a circuit which takes care of C-bias supply by grounding a tap of the voltage divider. In some cases this is more deisrable than providing each tube with a cathode resistor. The section of the voltage divider from chassis to B— carries all the current of all the tubes and consequently is less affected by the varying current in just one tube. A better stability of grid bias can then be obtained. However this is by no means fixed bias such as required by certain class AB output stages. In order to have real fixed bias it is necessary to employ batteries or a separate power supply. These cases will be discussed later under "special power supplies".

MULTIPLE SECTION FILTERS

Figure 7 illustrates a typical power supply for larger receivers employing

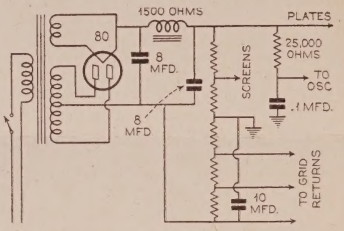

Fig. 6

two filter sections and placing the speaker field in the second section. The filter stage ahead of the speaker greatly reduces the hum introduced by the field itself besides lowering the hum level of the plate supply. The voltage divider serves as a bleeder to deliver semi-fixed bias to the driver stage. The output stage however, as well as all other tubes are self biased.

In Figure 8 you see a power supply for a really big set. The receiver in question employs three speakers. Two of the speaker fields serve as chokes for the filter while the first filter section contains a choke. This first section is tuned by means of the condenser across the choke. The combination is tuned to 120 cycles and being a parallel tuned circuit in series with the line it offers a high impedance to currents of its resonant frequency.

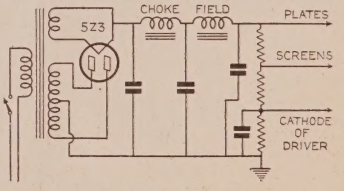

Fig. 7

The 10,000 ohm field of the big low frequency speaker does not take part in filtering. It Just acts as a bleeder across the power supply.

A.C.-D.C. CIRCUITS

A.c-d.c. receivers offer some new problems. As far as the circuit is concerned, very little variation is possible;

Figure 9 shows a tyical power supply of an up-to-date receiver. Let us take the problems one by one, beginning with the filaments because that seems easiest.

A series of tubes is available which is suitable for this service because all members of the series require the same filament current (.3 ampere.) In general, all the tubes are placed in series and a resistor is added so as to

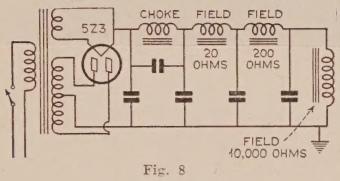

Fig. 8

provide the required voltage drop. This resistor is now generally placed in the power cord so as to remove the heat from the chassis.

When placing the filaments in series it makes quite a difference in which order they follow each other so as to produce the least hum. As one might expect hum is introduced due to leakage between the cathode and the filament; this leakage will in turn depend on the potential difference between the filament and the cathode. Since all cathodes are connected to the negative side of the power supply, it follows that the most critical tube should be placed at the negative end. This is generally the detector. Starting from that side one encounters first the detector, then the r.f. and i.f. stages, then the a.f. stages and finally the rectifier.

The B-supply has only about 120 volts to start with so it is not possible to employ high-resistance chokes. Consequently. the speaker field cannot serve as filter choke and it is generally connected across the B-supply. The maximum rating of the 25Z5 rectifier is sufficient for the average receiver but sometimes two of them are used in parallel. Sometimes one encounters a design which utilizes one section of a 25Z5 for the field supply and another section for the receiver proper.

Filtering a 60 cycle supply is twice as hard as removing a 120 cycle ripple Reactances of chokes are only half as much as for 120 cycles and reactances of condensers are twice as high. So, in order to obtain the same filtering at 60 cycles as at 120 cycles one would need chokes of double the inductance and condensers of double the capacity. Fortunately, the small a.c.-d.c. set has a relatively low gain and the set has no transformers. Therefore there can be no inductive pickup from any power transformer although there is a choke. Resistance coupling is usually employed which eliminates the dangers of hum pickup in audio transformers. One should not think however that the design of such a set is easy. Very careful placing of the parts is necessary if good results are to be obtained.

One filter section is usually all that is employed; large condensers are used and the choke can have larger inductance due to a relativelv low current.

Another problem with a.c.-d.c. sets is the fact that the chassis, if tied to the B— side becomes one side of the line and this may be the side which is not grounded. Accidental grounding of the chassis or the antenna wire would result in short circuits. The last danger is circumvented by placing a series condenser in the antenna lead and to make no provision for a ground connection.

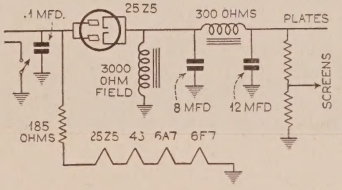

Fig. 9

There is still the possibility that the chassis may accidentally be touched by a grounded wire which may result in shorting the line. The only remedy seems to be to sever the connection between B— and chassis or to enclose the chassis in such a way that the consumer is not likely to touch it. These precautions are taken in receivers of this general type. A little reflection will show that disconnecting the chassis from B— results in additional difficulties of the design of r.f. circuits. For instance, the tuning condensers must now be nsulated from the chassis, or if they are not, a condenser between chassis and B— is employed to complete the circuit which is again likely to cause feedback and hum unless great care is taken.

Still another problem with a.c.-d.c. sets is their susceptibility to interference conducted along the line. The circuit of Fgure 9 shows a condenser connected across the line in order to help remove this trouble.

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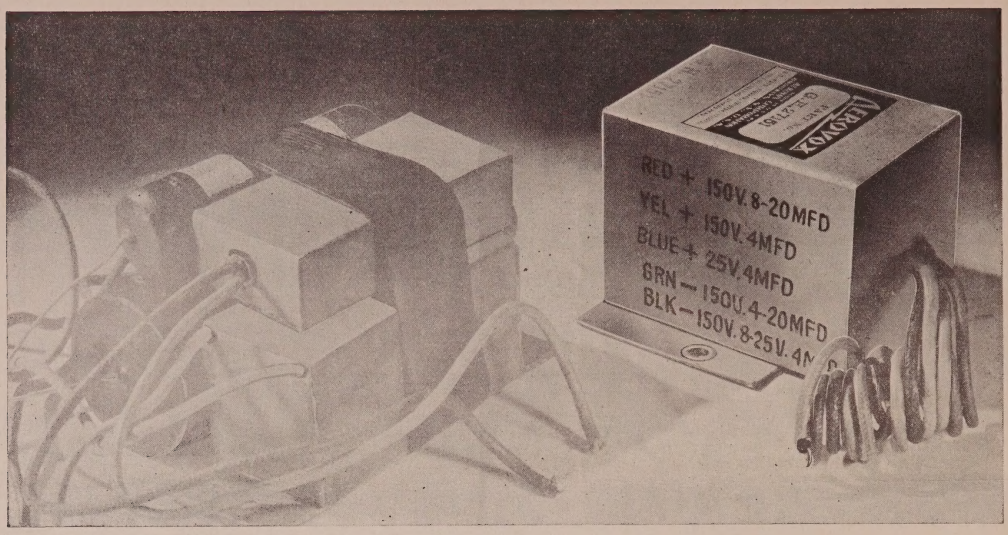

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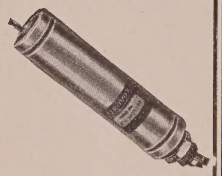

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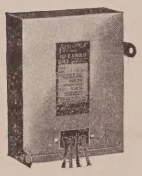

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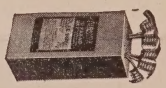

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